Ferroelectric Ceramic/Polymer Bimorph Sensor for Strain Measurement in Laminates

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First Interim Report

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1. Introduction

Flexural (or bending) piezoelectricity of a piezoelectric monomorph film may be enhanced by bonding two or even a number of multiple poled films to form a bimorph or a multimorph. The compliance of ceramic/polymer composite is generally greater than piezoceramics. We have produced calcium modified lead titanate, PTCa/copolymer of vinylidene fluoride trifluoroethylene, P(VDF-TrFE) and PTCa/Epoxy composites and have successfully embedded such composite films in glass-laminate structure and detected acoustic emission signals (see Final Report DAJA 45-93-C-0017). It is our objective now to produce bimorphs and multimorphs with these two different composite films of mixed (0-3 and 1-3) connectivity and provide surface bonded and embedded sensors to monitor strain in-situ and also to use them as ultrasonic transducers.

It is necessary to design bimorph (or multimorph) sensors capable of providing both sufficient force and a good displacement. The deflections, δ, of a monomorph under a bias voltage V, is given by[1]:

$$\delta = \frac{3}{2} d_{31} \frac{VL^2}{t^2} \qquad \text{.............. (1)}$$

where L is the length of a monomorph and t its thickness. The converse effect will not be according to the inverse of equation 1 as the deformation due to an applied field is governed by $d_{ij} = (dx/dE)$ which is not the inverse of (dE/dx), where x is the strain. In addition, the applied field will produce uniform strain along the length of the bimorph so that it will be bent in the shape of a circular arc, in contrast to a more complex shape produced by non uniform mechanical strain [2]. A high level of force at the expense of a modest extension may be obtained by an appropriate choice of low ratio length/width of the bimorph assembly and it should be noted that maximum force decreases with increasing film thickness. The frequency response of the bimorph device is expected to be flat from DC up to its maximum required frequency, bearing in mind that there will be a mechanical resonant frequency where the response is highest.

2. Fabrication Technique

For the initial trial two different composite films of PTCa/P(VDF-TrFE) and PTCa/Epoxy are to be poled at a field of up to 2×10^7 V/m at a temperature of 90^0C for a poling time of one hour. The poling is to be performed by applying vacuum deposited aluminum electrodes on both surfaces of each film. Al-electrodes will then be removed with 10% NaOH solution. Initially, two layers will be glued in series so that the directions of polarisation of both layers are the same. Then it will be cut into two parts and these will be glued to one another, head-to-head.

Following the fabrication the piezoelectric d_{31}- coefficients will be measured.

It is anticipated that the trial fabrication will be completed by the beginning of February 1996 when the characterization will commence.

We have embarked on this proposed structure based on our literature survey in this area 3-12.

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